Optofluidics

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Abstract

Optofluidics refers to a class of adaptive circuits that integrate optical and fluidic devices. Familiar examples include liquid crystals and dye lasers. The introduction of liquids in the optical structure enables flexible fine-tuning and reconfiguration of circuits so they can perform tasks optimally in a changing environment. I will discuss how the emergence of fluidic transport technologies at the micron and nanometer levels opens possibilities for novel devices.

Optical devices are in general fabricated with solid materials such as glasses, metals, and semiconductors. It is also possible to realize a broad spectrum of commonly used optical devices with fluids [1, 2]. For instance, the curvature of a liquid surface due to surface tension can be used for lensing. Optical waveguiding realized in a liquid stream surrounded by a lower index fluid such as air is another example. While, fluids have been used in optics for a long time (index matching fluids, oil immersion microscopy, liquid crystals, dye lasers, etc), the emergence of microfluidics has broadened dramatically the range of possibilities. Microfluidics allows the manipulation of fluids (liquids and gases) with fine resolution (~100 nm is currently feasible) and high complexity (thousands of valves on a single chip). Microfluidics was developed for the integration of biochemical functions on a single chip. These devices can also be used to synthesize novel optical devices since the materials with which they are fabricated (glassed and polymers) can have excellent optical properties. In an optofluidic device the fluids transported by the microfluidic channels become an integral part of the optical system. Therefore, such systems can be readily reconfigured by modifying the distribution of the liquids. Adaptation is one of the key features of optofluidic circuits.

An adaptive system can often be used as a sensor if the adaptation mechanism is what we wish to measure. In optofluidics, the adaptation mechanism is a fluid in which chemicals or other objects can be suspended. The advantage of such sensors is generally due to the high integration level that is possible since the same toolkit used to realize biochemical reactions can also be used for synthesized desired optical functionalities such as imaging and spectroscopy.

[1] Psaltis, D, S. Quake, C. Yang, *Developing optofluidic technology through the fusion of microfluidics and optics,* Nature, July 2006.

[2] www.optofluidics.caltech.edu

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